ALLIS-CHALMERS

ELECTRICAL REVIEW

September • 1944

"Dollhouse" factory layouts are proving a big help in planning electrical equipment installations. Where several possibilities can be considered, realistic scale models of factory floor, aisles, machines and even workers offer a complete accurate picture at a glance.

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ALLIS-CHALMERS

ELECTRICAL REVIEW

C O N T E N T S

PROTECT YOUR MOTORS FROM INVASION!

Suitable and adequate protection is the password to longer life and reduced production interruptions. It pays to follow what thousands of industrial applications have proved to be true!

G. Byberg and C. D. Lawton

MOTOR AND GENERATOR DIVISION • ALLIS-CHALMERS MANUFACTURING COMPANY

● Greater recognition is regularly being directed to the necessity of suitably protecting electrical apparatus, particularly the rotating type, against deterioration due to harmful conditions present in the locations where they must operate. Users of rotating equipment are realizing more and more the importance of physical protection which will prolong the useful life of machines and reduce costly interruptions of production. The economic justification of the additional expense for providing such protection has been fully substantiated by the experience of years.

The evolution in industry has brought about a special demand for motors with characteristics that will result in longer life expectancy than the standard open type machines. The basic reasons for the evolution of various degrees of enclosures and protective features are:

1. Protection of insulation against unduly rapid deterioration from injurious agents present in the surrounding atmosphere.

2. Protection against collection of dust and dirt in the ventilating ducts and passages which would seriously hinder or obstruct normal ventilation.

3. The desirability of protecting current collecting or other exposed live parts, such as collector rings on synchronous or wound rotor induction motors and the commutator of d-c machines, against dirt and moisture, which dangerously reduce the insulation value between parts of different potential or cause short circuits. (Also, against dripping liquids or dust, dirt, oil, metal particles, etc., falling on exposed live parts.)

4. The supplying of requisite amounts of clean ventilating air at the correct temperature.

5. Protection against occasional sparking from commutator or collector ring where machines are subjected to high momentary overload and where inflammable materials are nearby.

6. Protection against sparks or hot flame escaping into explosive atmosphere.

7. Protection to persons who might accidentally contact live or moving parts.

8. The reduction of objectionable windage and/or magnetic noises.

AT LEFT: One kind of defense on the vital home front is the protection afforded motors like this performing 'round-the-clock in America's war plants. The squirrel-cage induction motor driving this machine tool through a Texrope Drive is totally-enclosed, fan-cooled.
—*Robert Yarnall Richie photo.*

Types of enclosures

There are many types of enclosures, suitable for many different environments and operating conditions. All types of enclosures perform some function of keeping foreign matter from getting into the machine. The most common types are:

1. Drip-proof
2. Semi-protected
3. Protected
4. Drip-proof protected
5. Splash-proof
6. Base-ventilated
7. Pipe-ventilated
8. Separately ventilated
9. Totally enclosed, non-ventilated
10. Totally enclosed, fan-cooled, secondary ventilated
11. Totally enclosed, with air coolers.

This discussion will be limited to the drip-proof type which is the most common type of protection and which is now becoming almost universal in its application.

ASA Standards define the drip-proof machine as follows:

"A drip-proof machine is one in which the ventilating openings are so constructed that drops of liquid or solid particles falling on the machine at any angle not greater than 15 degrees from the vertical cannot enter the machine either directly or by striking and running along the horizontal or inwardly inclined surface."

Certain types of machines are, of course, inherently drip-proof, including normally enclosed machines, like turbo-alternators, large synchronous condensers, large two-pole induction motors, and those falling in the classes of totally-enclosed, or totally-enclosed, fan-cooled types. Splash-proof and waterproof machines obviously also are drip-proof.

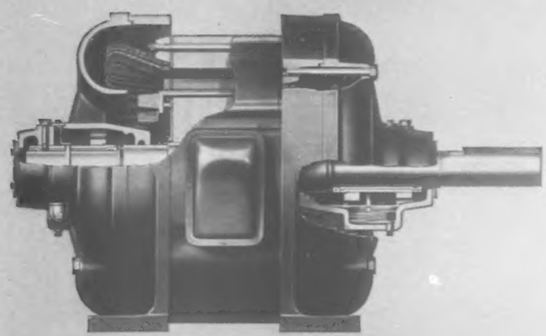


Fig. 1 — Sectional view of small open type squirrel cage induction motor.

Fig. 2 — Induction motor in Fig. 1 with drip-proof covers added.

Fig. 3 — Drip-proof direct-current motor of intermediate size.

Fig. 4 — Drip-proof wound rotor induction motor of relatively large size.

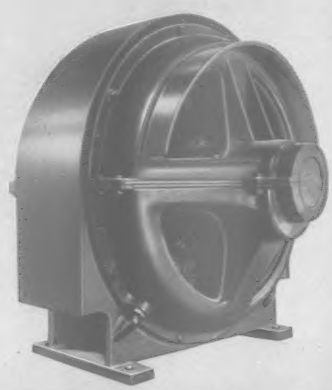


Fig. 5 — Synchronous motor of intermediate speed with drip-guard over upper ventilating openings.

Fig. 6 — Small high speed drip-proof d-c generator.

Drip-proof protection can be obtained on all bracket-bearing type machines, and practically all pedestal type coupled or engine type machines. The only instance where such protection could not be obtained is where the machine is located in such a confined space as to prohibit the use of requisite covers. In conforming to the ASA definition limitation of 15 degrees from the vertical, it may not always be possible to meet that condition exactly in the case of large diameter, low speed, synchronous or induction machines without resorting to somewhat elaborate and expensive covers.

Ventilation considerations

The phrase *"drip-proof"* sounds relatively simple, and in the case of most high-speed, bracket-bearing machines it is, except for one thing — ventilation. Referring to Fig. 1, showing the cross section of a small open type squirrel cage motor, it will be seen that the armature core is exposed, and that the end shield part of the bearing bracket has an *"inwardly inclined surface."* So, in order to meet the definition, covers are added and the appearance shown in Fig. 2 is obtained.

The ventilating air enters through the openings of both bearing brackets and, after passing through its directed paths, discharges through the openings in the stator end frames back of the armature core. The addition of drip guards on the bracket has done little to restrict ventilation at the air intake, but the stator cover has to some extent hampered free discharge, and a greater pressure would be required to discharge the normal volume of air through the cover openings into the free air. Consequently, there will be a slight reduction in the volume of air passing through the motor.

This effect is more pronounced in small machines at low speed (i. e., low peripheral rotor speeds) than in large motors (with higher peripheral rotor speeds) since the pressure which the small rotor and its fans can build up would quite naturally be less.

Because of this effect on ventilation, existing manufacturing standards consider all motors of general purpose ratings (200 hp and smaller at speeds 450 rpm and higher) as 50 C rise machines. Large high speed machines can ordinarily be built to maintain rated open type temperatures, but large machines of very

low speeds may have greater rise due to further restriction of normally lower ventilation.

Other cases of drip-proof bracket-bearing machines also offer interesting facts. Fig. 3 shows a high speed d-c motor and Fig. 4, a large high speed wound rotor induction motor, on which covers have been added over the top-half ventilating openings. Obviously, neither of these motors would be drip-proof within the full requirements of the definition without these covers. While the fields of the d-c motor and the stator of the wound rotor motor are well protected, neither the commutator of the d-c machine nor the collector rings of the wound rotor motor would be adequately protected in the full sense of the definition.

The rear end brackets may have drip-lips or canopies as shown by Fig. 5, or have the upper bracket either cast solid as shown by Fig. 6 or with openings of such size, shape and arrangement as to render them inherently suitable.

Differences in d-c and a-c units

It may be well to point out the principal difference in the ventilating schemes inherent in d-c and a-c machines. In the d-c machine the ventilation is essentially axial only, that is the air enters one end and discharges at the other. The a-c machine utilizes a combination of both axial and radial ventilation ducts. Of course, in machines such as shown in Figs. 4 and 5 the construction imposes some restriction on free discharge, requiring a larger airpath area back of the stator core.

In the case of lower speed machines, especially those of the synchronous or induction type, the diameter is usually quite large as compared to length. Also, in the case of smaller ratings the rotor peripheral speed may be so low that the machine may not ventilate well naturally if extreme care is not taken in applying enclosures.

In extreme cases of the very low speed bracket-bearing machine, shown in Fig. 7, due to low rotor speed the fan action is limited, and it is not practicable to resort to the type of stator yoke shown in Figs. 4 and 5. However, an external canopy of sheet steel can be bolted to the yoke, providing the requisite protection, if it is spaced a sufficient distance from the yoke so that the discharging air can pass through that space freely.

Similarly, a low speed engine type machine having a stator as shown by Fig. 8 is sometimes a problem. The circumferential stator yoke openings can be protected in the manner described for the lower speed bracket-bearing machine (shown by Fig. 7). The end-protection is more difficult due to the necessity of taking care of the angle of 15 degrees from the vertical.

By referring to Fig. 9, it can readily be seen that, at an angle of 15 degrees subtended from the inner edge of the end-shield (point A), any dripping liquid coming in at that angle may fall into the lower stator core and coils. For marine work it may even be necessary to provide for an angle of 30 degrees from the vertical in order to take care of the change in the angle due to the rolling or pitching of the vessel. About the only way in which this can be accomplished is to resort to some sort of louver arrangement, as shown by Fig. 10, or by adding canopies ("C" as shown in Fig. 9).

Fig. 7 — Exceptional case of very low speed machine with special drip covers.

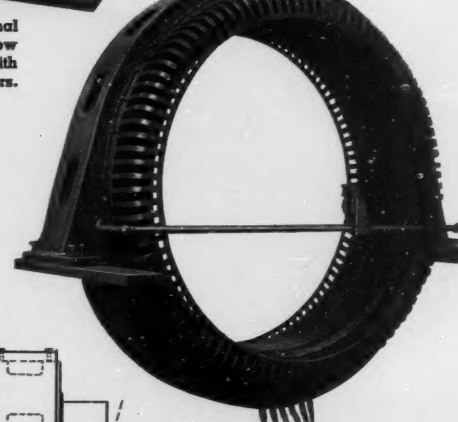


Fig. 8 — Stator of standard open low speed engine type synchronous machine.

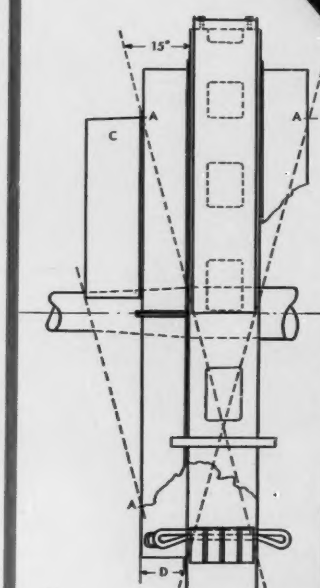


Fig. 9 — Consideration for drip-proofing a low speed synchronous machine of large diameter (at left).

Fig. 10 — Synchronous machine with drip-proof covers having louvers to provide additional protection.

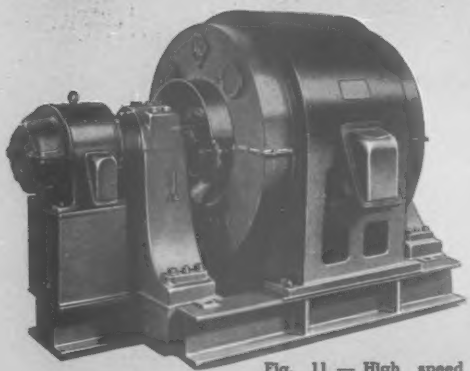


Fig. 11 — High speed drip-proof pedestal bearing type a-c machine.

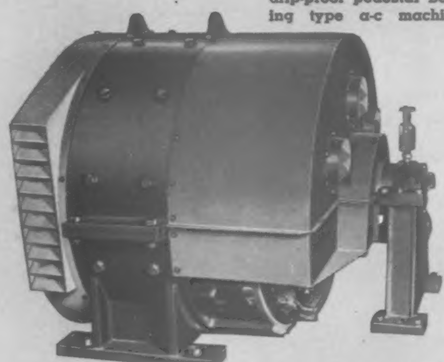


Fig. 12 — Drip-proof direct current generator for marine service.

Fig. 13 — Small vertical squirrel cage induction motor with separate drip cover.

Fig. 14 — Vertical general purpose motor with louvered drip covers. To adequately "drip-proof" a motor for marine application, like the one above, it is usually necessary to provide for more than the ASA defined 15 degrees from the vertical. In order to take care of the change in the angle due to the rolling or pitching of the vessel, provision for an angle of 30 degrees is sometimes considered necessary, and this is generally accomplished by means of louvers.

As the diameter decreases, or the number of poles decreases, the coil stickout becomes proportionately greater, and by reducing dimension "A-A" (in Fig. 9) and decreasing "D," it may be possible to obtain the requisite protection. This is evident from Fig. 11, which shows a high speed synchronous machine.

Other special covers

Fig. 12 shows a direct-current generator of intermediate size and high speed and indicates the somewhat elaborate covers required to drip-proof a machine for marine service under certain conditions.

Vertical machines present a somewhat different case because ventilating openings, in the bearing-carrying bracket or bridge on the upper end, are completely exposed to drip.

In some types of machines the complete closing of upper ventilating openings would be prohibited since it would completely disrupt the ventilating scheme. For that reason it is often necessary to resort to separate covers, as shown by Figs. 13 and 15.

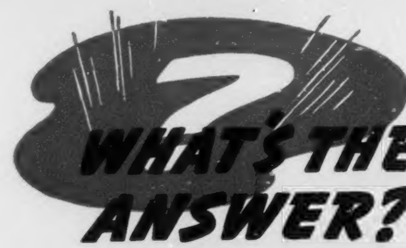
For some types of machines it is practicable to use louvered covers, as illustrated on the d-c machine in Fig. 14.

The decision of whether a motor should be drip-proof involves consideration of its location and future possibilities of its being moved to some other location. The main purpose of drip-proof features is to protect the motor from falling liquid, but obviously in any location where strong drafts or spray are present, the falling liquid will be deflected to an angle greater than 15 degrees from the vertical, and some other protection should be used.

Fig. 15 — Low speed vertical induction type motor with separately-mounted drip covers, which do not disrupt the ventilating scheme.

Fig. 16 — Vertical synchronous machine with solid upper bearing housing and drip guard over air discharge opening.

COMMON CONVERSION FACTORS listed in the JUNE ELECTRICAL REVIEW included .778 as the factor for converting Btu to ft.-lbs. Correct factor is 778.



Question—Is a hot cathode type mercury arc rectifier practical for use in plating machine parts?—O. L. K.

Answer— No, because the currents used for electrolitic plating are generally high, in the order of 1,000 amperes, while the d-c voltage is only about 12 to 30 volts. This makes a rectifier uneconomical both from a cost and efficiency standpoint when compared to other equipment.

The hot cathode type rectifier is rated in amperes and not in kw or kva. Therefore, the cost of a low voltage high current unit is approximately the same as a high voltage unit of the same current rating. This makes prohibitive the cost of a rectifier with low voltages, such as needed in plating work. Low efficiency results because the arc voltage drop is an appreciable percentage of the d-c voltage.—W. E. G.

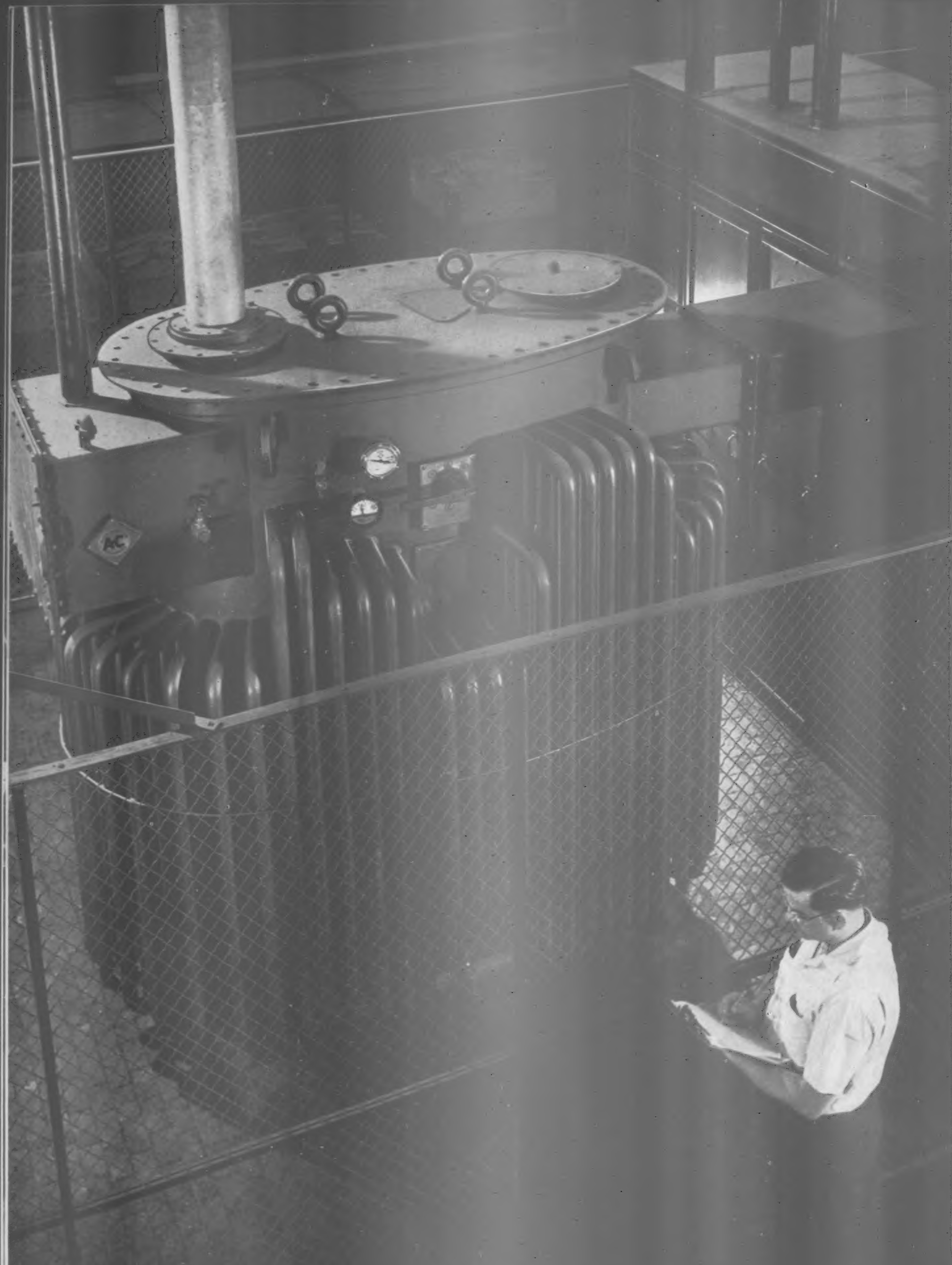
Question— American practices not only permit, but specify cascading of low voltage air circuit breakers. Why can't oil circuit breakers be cascaded by the same method? — L. J. C.

Answer— The practice of cascading low voltage air circuit breakers arises from economical considerations rather than those of desirable engineering. It does, however, permit having one breaker large enough to take the short circuit current and provide the desirable number of feeder circuits for switching and overload protection of such circuits within the capacity of the smaller breaker.

This practice is not commonly followed with oil breakers because the higher voltage circuits on which they are used ordinarily are of sufficient importance to justify full short circuit protection on each circuit. Occasionally oil breakers are installed where the feeder breakers do not have full interrupting capacity for the circuit and are protected by a larger incoming line breaker. In such cases the smaller breakers are locked out under short circuit conditions and the short circuit taken by the larger breaker. This is easy to arrange when overcurrent relays are used to trip the breakers.

Low voltage breakers are not usually tripped from separate overcurrent relays, and in cascading, the required selective operation is obtained by having the instantaneous overload trip on the large breaker set low enough so that it will open on any current close to or exceeding the capacity of the smaller breaker. In such case, both breakers open and the smaller breaker may suffer some damage, and require maintenance before it can again be used. Such a practice would neither be practicable nor safe on larger power breakers. — H. V. N.

"What's the Answer?" is conducted for the benefit of readers of ELECTRICAL REVIEW who have questions on central station, industrial or power plant equipment. Send all questions to the Editors of ELECTRICAL REVIEW.


AC

AERIAL PHOTOGRAPHY TRICK SIMPLIFIES SWITCHGEAR INSTALLATION ENGINEERING

Component parts of unit—movable and fixed portions, swinging panel—are diagrammed separately, and all keyed to a master chart which shows connections and wiring between parts.

T. G. A. Sillers

SWITCHGEAR DIVISION • ALLIS-CHALMERS MANUFACTURING COMPANY

● Wiring diagrams represent a major portion of the engineering time involved in making drawings for a switchgear installation. Methods of making these diagrams have varied greatly, with a trend toward simplification and standardization of circuits.

Full line diagrams with each circuit individually shown, and frequently including a full three-line primary circuit, were supplanted by diagrams where connections were grouped in functional or directional runs and individual leads were identified by coded markings.

This latter system resulted in diagrams where individual circuits could be followed with comparative ease, but on installations involving several primary circuits, large, cumbersome drawings still resulted. In many cases these were cut into sections by the user to simplify their use, as the usual requirement of these drawings consisted of wiring or checking only a portion of the circuits involved. Since these diagrams were made with the wiring grouped in a manner corresponding somewhat to the physical arrangement of the equipment, cutting into sections was easily done, but complete section identification was not obtained.

Fig. 2 shows a typical old-style drawing. The difficulty of tracing any individual relay or meter connection through the maze of wires indicated is quite obvious, and becomes only too prominent after several hours of concentrated checking.

AT LEFT: Machine shop substation is one of many located at load centers throughout a highly efficient war plant. Their ratings range from 750 to 2,000 kva.

System of section drawings

Then, a trick was borrowed from the practice of recording aerial photography where the subject is digested piecemeal and the pieces then matched to tell the complete story. Similarly a switchgear drawing

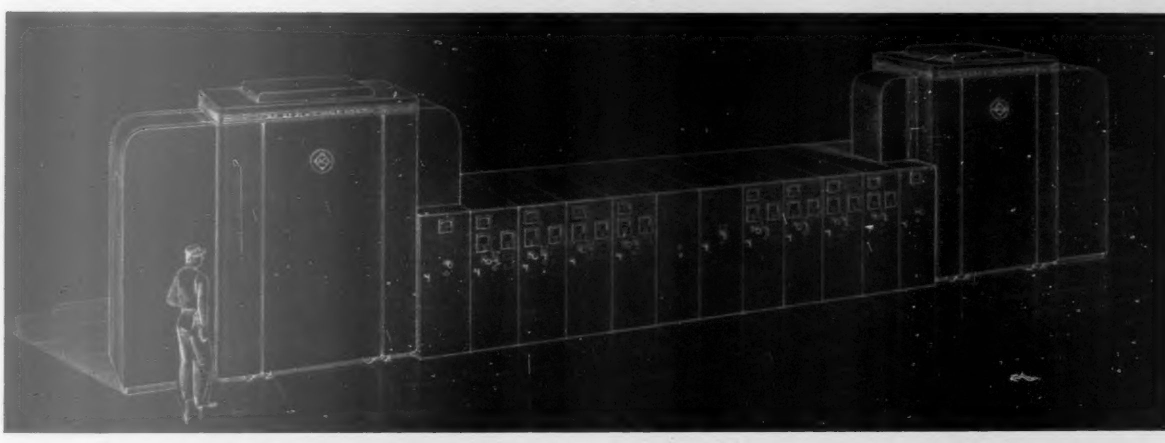


Fig. 1 — Vertical lift switchgear units for modern unit substation layouts are engineered more easily with new, simplified wiring diagrams. This one serves a large industrial plant with power for motors and lighting, stepping down from 13,200 volts to 2,300 volts.

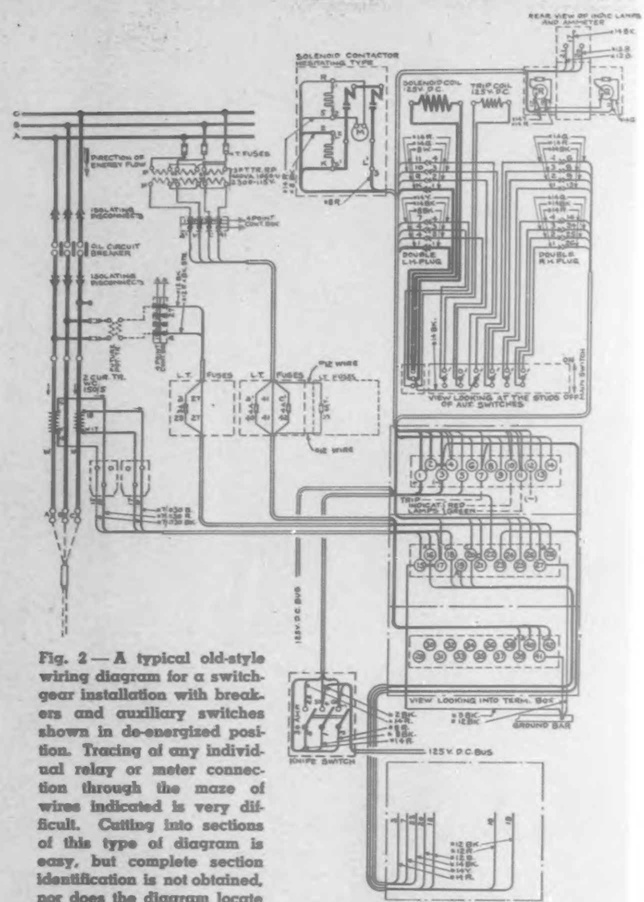


Fig. 2 — A typical old-style wiring diagram for a switchgear installation with breakers and auxiliary switches shown in de-energized position. Tracing of any individual relay or meter connection through the maze of wires indicated is very difficult. Cutting into sections of this type of diagram is easy, but complete section identification is not obtained, nor does the diagram locate position of parts.

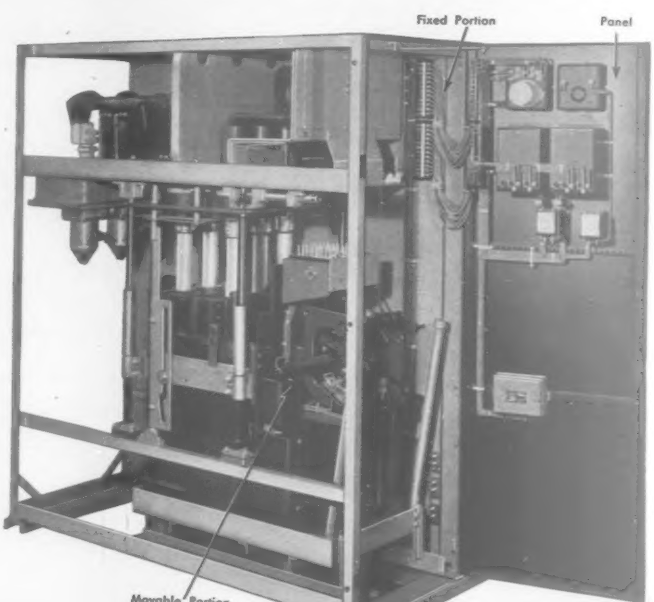


Fig. 3 — Component parts of a switchgear unit, each of which is diagrammed separately in the new system of drawing wiring installations, as shown on opposite page.

scheme having separate diagrams for each component part of a switchgear unit was evolved. That is, separate drawings are made for the movable portion, fixed portion and swinging panel of each switchgear unit. These component parts are shown in Fig. 3. An additional drawing, Fig. 4, known as the "Master Wiring Diagram," serves as an index to the detailed drawings of the component parts and shows all external wiring and internal connections between units. This "Master Wiring Diagram" shows all wiring of the switching equipment which must be done on installation, except in those few special cases where a portion of a unit, such as a panel or a superstructure, is removed for shipment or some similar reason. This drawing also carries complete identification as to adjacent units.

The ease with which the sectionalized diagrams may be checked is apparent from Figs. 5, 6 and 7. Each component may be checked with its drawing and then eliminated from further consideration.

A one-line diagram is normally provided for the entire installation. This drawing includes a list of meters and relays, with rudimentary schematic diagrams indicating the sequence of connection, instrument transformer ratios and polarity relationships. For complicated installations a full schematic diagram is made. Reference to the master diagram shows the external connections to be made on installation of the equipment.

The movable portion diagram, Fig. 6, shows all wiring on the circuit breaker. The fixed portion diagram, Fig. 5, shows the instrument transformer connections, leads to hinge wiring to the panels, and to the secondary wiring disconnecting contacts to the circuit breaker as well as wiring for incidental items such as limit switches, space heaters, etc., which may be included. The panel diagram, Fig. 7, shows all panel wiring.

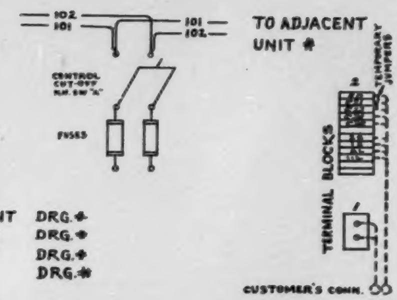
"Master drawing" is key

Each section diagram is simple and easily read. In the cases of identical components, one drawing covers the wiring of more than one unit. The group of drawings required for any installation may be bound for reference, the index on the master diagram, Fig. 4, referring directly to the part drawing required for any purpose. Men wiring, modifying or checking any job need only refer to the drawing of the part in which they are concerned. This drawing is small enough to readily locate each lead and still have individual connections sufficiently spread out for easy tracing.

Where diagrams of the sectionalized type are provided, an instruction sheet including the typical diagrams shown in Figs. 4, 5, 6 and 7 has proved to be ample for the use of engineers, draftsmen, wire men and inspectors.

In the short time this drawing system has been in use, the ease with which the complete wiring of metal-clad switchgear equipment can be methodically checked has been clearly demonstrated. With the new system, large cumbersome drawings with many tangled lines are no longer necessary.

UNIT NO.	# 1
UNIT DESIGNATION	INCOMING LINE
FIXED PORTION WIRING DIAGRAM	DRG. # R -
PANEL WIRING DIAGRAM	DRG. # R -
MOVABLE DIAGRAM WIRING DIAGRAM	DRG. # RG -



REFERENCE DRGS:-
GENERAL ARRANGEMENT DRG.#
SINGLE LINE DIAGRAM DRG.#
PANEL ARRANGEMENT DRG.#
BILL OF MATERIAL DRG.#

Fig. 4 — Typical master wiring diagram used in simplified system for engineering switchgear installations.

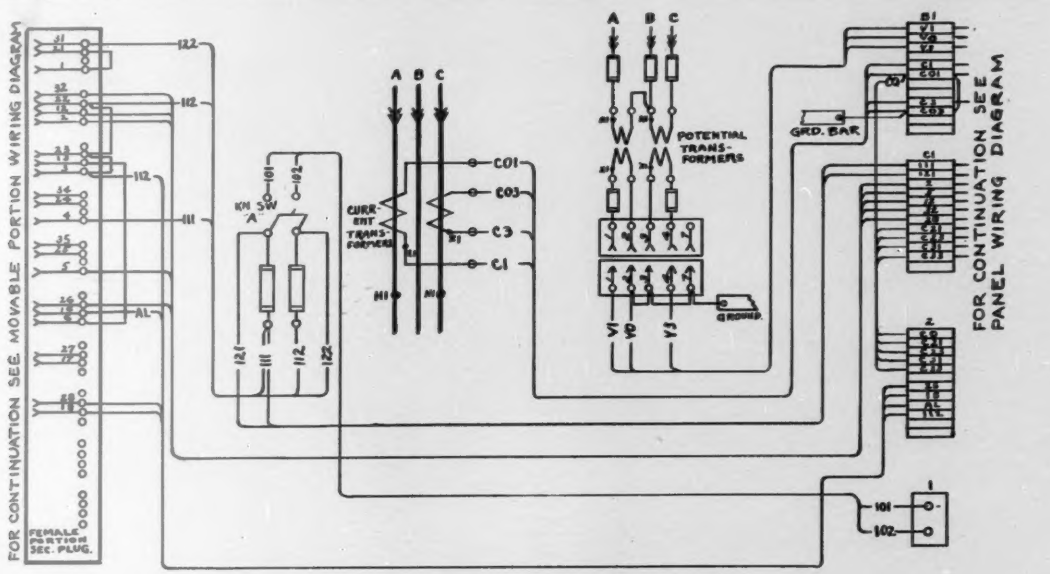


Fig. 5 — Typical wiring diagram of fixed portion.

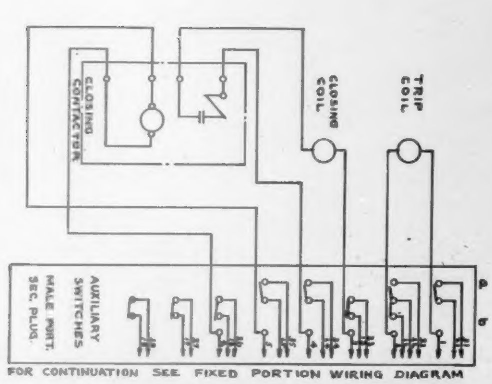


Fig. 6 — Typical wiring diagram of movable portion.

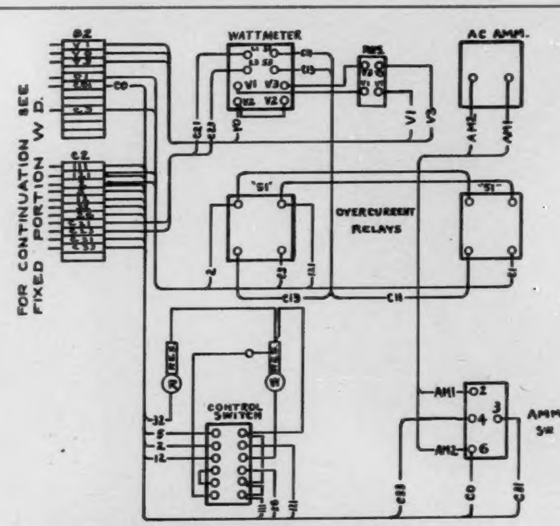


Fig. 7 — Typical wiring diagram of panel.

"DOG TAGS" FOR INDUSTRY'S PRODUCT ARMY

Trade marks have been easily remembered signs of identification since the early days of product craftsmen. Here's how countless names have served as simple but invaluable signatures for manufacturer or distributor.

D. Journeaux

PATENT ATTORNEY • ALLIS-CHALMERS MANUFACTURING COMPANY

● It has been said that trade is the life blood of our civilization, and ancient records painstakingly unearthed and deciphered by archeologists are proof that trade has gone on since time immemorial. Indeed, trade may go back almost to the creation of man, for did not Adam trade a rib for a wife?

Trade nowadays is hardly separable from advertising, and while the use of newsprint and radio for advertising is necessarily of relatively recent origin, other forms of advertising are quite ancient. Everybody knows that tradespeople have long resorted to adorning their place of business with some distinguishing and ornamental sign, but perhaps the most ancient form of advertising is the trade mark.

What is a trade mark?

A trade mark, in whatever form it may be applied to an article of commerce, is the signature of its maker or of its distributor. Originally, the work of a particular craftsman may have been distinguishable by nothing more than the peculiar shape or decoration of his product, such as a characteristic curve in a stone axe, or a geometric design on a pottery bowl, but the "freezing" of such characteristics within the different tribes and nations has caused the products of generations of craftsmen to remain identical from biblical times to this day.

One fine day in the dim past, however, some craftsman or artist — for the two are often indistinguishable — began marking his work with some personal sign to identify it as his own product. That day the trade mark was born. If the maker of the goods was able to write (assuming that writing had been invented) it was obvious for him to inscribe on the goods that they were made by him. If he was illiterate, he could use any arbitrary mark his own fancy dictated.

No doubt many craftsmen in the past have marked their work merely for their personal satisfaction. But, while we trust that the pride of the craftsman for his work is still alive, the trade mark, in most cases, is now merely one of the devices used by manufacturers for influencing the choice of buyers of their goods.

Manufacturer's name

The most obvious use of a trade mark is to enable the buyer to recognize goods as being of the same make as goods he has found desirable previously, because of their good quality, their low cost, their availability or some other advantageous feature. For this purpose the name of the manufacturer is probably as valuable as any fanciful mark, but as most prominent manufacturers are corporations having complex names, the name is often reduced to one significant word, such as Carnegie, Ford, DuPont, Bendix. The name of the manufacturer may also be reduced to its initials: RCA, S&C, O-B, C-H. A more elaborate system of abbreviation results in such names as Autelco, Alcoa, Sparton, Barcol, Cee-tee-co.

Trade marks consisting of a fanciful design have been and are still widely used, but it is desirable that the design itself have a name which is well adapted for use in conversation and in print. Crescent, Crown, Star, Eagle, Keystone are trade marks that can be used in written form as well as in pictorial form.

Bearing in mind that a particular trade mark applied to a particular kind of goods can be the property of only one manufacturer or seller, it is obvious that a mere geographical name does not usually serve well as a trade mark. Geographical nicknames, however, are often used, as Badger, Hoosier, Buckeye, Hub, Gotham, Cream City.

Other words in common use are often taken as trade marks without any apparent reason, such as Parabola (for needles), Aetna (for bearings), Pyramid (for motor brushes).

Suggestive trade marks

A trade mark should not be descriptive merely of the goods to which it is applied, for a descriptive name would designate the goods of any manufacturer. It may well be a name which, while being distinctive enough to identify clearly the product of one particular manufacturer, is also suggestive of the goods to which it is applied or of their function or use. Such a

AT LEFT: Before long another U. S. Maritime Commission Victory ship will head out to sea, and part of its power plant will be this low pressure spindle for which the blading shroud ring is being machined.

trade mark may be derived from the name of the manufacturer: Dowmetal magnesium alloy, Beldenamel insulated wire, Cetron photo-electric cells, Edicraft vacuum cleaners, Curtistrip fittings, Romex cables. It may hint more or less broadly at the nature of the goods: Polaroid polarizing media, Electrite insulation, Dualarc welding machines, Globar heating resistors, C-O-Two fire equipment, Vari-amp feeder voltage regulators.

Sometimes the connection between the trade mark and the goods is less apparent; the mark may then relate to the manufacture of the goods, to some detail of their construction, or may express a mental image of an action or thing associated with the goods: Clearsite fuses, All-In-One ground clamps, Fish Spine insulation, Colortop fuses, Frog Leg d-c generators and motors, Crowsnest ladders, Circularloom flexible conduit, Edgerest resistors, Cool Spot fans, Dairywhite corrosion resistant alloy, Tite Bite conduit fittings, De-ion circuit breakers. The ways in which the goods are used is referred to in Clip-On portable meters, Klixon thermostats, Screwit insulators, Slip-In fixture studs, Add Here wiring.

THE INITIALS of a manufacturer, when used as a trade mark, are often written in a distinctive manner.

Psychology in trade marks

The choice of trade marks like these does not seem to involve much more than judicious application of the principles of fair trade and of sound advertising. Many trade marks, however, appear to have been prescribed by a psychologist, since their intent is obviously to dispose favorably any one seeing them toward the goods to which they relate, regardless and perhaps even in spite of, any previous acquaintance with the goods.

The most obvious way of favorably presenting an article of commerce is to set forth its special qualities. This is done more or less directly in such trade marks as Arkless fuses, Hevi-Duty furnaces, Hygrade lamps, Never-Creep guy anchors, Nokorode soldering flux, Quick-Clean motors, Rite Hete heating pads, Safecote insulated wire, Seal-Clad motors, Shakeproof lockwashers, Ultra-Speed drives.

A more subtle way to impress the qualities of a product on the public mind is to use as a trade mark the name of a person, character, animal or thing well known for its qualities such as Ajax, Hercules, Faraday, Big Boy, Champion, Monarch, Rex, Master, Pioneer, Pacemaker, Puritan, Giant, Bulldog, Beaver, Brown Mule, Bear Cat, Black Beauty, Diamond, Lightning, Gem, Big Ben, Star, Eclipse, Motor Cop. The name may be compounded to indicate the general class of the goods: Air Chief fans, Electromaster heaters, Power King tools.

When a trade mark is to apply to a number of different products which cannot all be suggested by a common name, it is much easier to adopt some laudatory adjective as Easy (or E-Z), Favorite, Famous, Handy, Ideal, Magic, Peerless, Standard, Royal.

If even this appears to be too specific, a name used as a trade mark can be impressive merely as the result of the connotation of respect or awe of its ordinary meaning: Reliance, Economy, Empire, Capitol, Gold Medal, Perfection, Excelsior.

Finally, a trade mark may consist of a coined word without any apparent derivation — such as Kodak, Marfak, Nylon, Saran.

Prefixes in coined names

Whether a word used as a trade mark or, as it is sometimes called, a trade name, be a common word or a coined word, it should be easy to remember, easy to pronounce, and easy to spell. In coined names these characteristics may be enhanced by the inclusion of familiar prefixes and suffixes, which may in themselves be complete words or parts of words spelled conventionally or purposely misspelled. Some of the more popular prefixes are:

Auto — Indicating some automatic feature: Autocall signaling systems, Autophone telephones.

Double — Indicating a duplication of parts or features or exceptional excellence: Double-Duty lathes, Doublenclosed motors, Doubleton balanced pumps.

Du or Duo — Conveying the same meaning in a less obvious form: Duplate laminated glass, Duo Therm heaters, Duo-Seal vaporproof fixtures.

THE GLOBE is a popular trade mark in both written and pictorial forms.

Ever — Indicating permanency: Eveready batteries, Evergrip connectors, Everlock terminals.

Multi — Indicating multiplicity of features or qualities: Multifinger switches, Multigrip floor plates, Multivolt resistors.

Neo, New, Nu — All indicating something new: Neobeam oscilloscope, Neotron timers, New Arc electrodes, New Process cable, Nu-Bilt motors, Nucode transformers.

No or Non — Denoting quality or simplicity by indirection: Noark fuses, No-Bolt fittings, No-Fray cords, Nonskore bearing bronze.

Super — Widely used and abused to indicate excellence: Super-Frax refractories, Superstat thermostats, Supertex cords.

Tele — Indicating operation at a distance: Telecell batteries, Telechron clocks, Telecode relays.

Therm — Relating to heat: Thermoplax plastics, Thermotex heating pads, Thermo-Watt tank heaters.

Tri or Triple — Indicating three features of high excellence: Tri-Branch-Fuser panels, Tri-Volt

A CENTAUR at the chase is a subtle hint to the manufacturer's name.

transformers, Triple Seal tube fittings, Triple Duty boilers.

Uni- Unitary construction: Uni-Cell batteries, Uni-top circuit breakers, Uniflex insulation.

Suffixes

Suffixes are more numerous and more widely used, perhaps under the influence of chemical terminology.

-air or -aire Is now popular in connection with the control of atmospheric conditions: Arcticaire fans, Control-Aire humidifiers, Frigidaire refrigerators.

-eer or -ier Indicates a device for performing some predetermined function: Lightolier lamps, Tumbolier switches, Combustioneer stokers.

-matic Is a convenient contraction of automatic or pneumatic: Hydromatic tires, Port-O-Matic radio sets, Speedomatic saws, Oil-O-Matic motors, Inter-Matic time switches.

-et or -ette Is generally used to give the impression of small size: Arrolet conduits, Electrolet fittings, Dry-O-Let clothes dryers, Ventilette fans, Kadette radio sets, Scoopette reflectors.

THE BULLDOG has well known qualities, readily brought to mind by this trade mark.

-ex Is a Latin ending which gives a word a learned tone. It is occasionally the residue of another word in which it appears as prefix: Conex connectors, Fibrex tree wire, Regulex exciters, Autex extension cord reels.

-ax, -ix, -ox, -ux May be simply modified forms of ex, or may be part of coined suffixes: Thermoplax molding compound, Super-Frax refractories, Scrulix guy anchors, Latox insulated wire, Isolux reflectors.

-flex Immediately brings to mind the thought of flexible goods: Cresflex cables, Arroflex conduit straps, Uniflex insulation.

-tex Is often evidently an abbreviation of textile: Paratex insulating tape, Fibretex pressboard, Vartex varnished cloth.

-ite Is a common suffix indicating a relation, probably taken over from the terminology of chemistry and mineralogy: Armite insulating paper, Micanite insulation, Codite molding compounds, Permite castings, Silkenite insulated wire.

-lite Is a suffix for which we are indebted to the lighting industry: Powerlite lanterns, Practi-Lite lamps, Prest-O-Lite batteries, Celestialite light globes.

-loy Is commonly used as a contraction of "alloy": Carboloy cemented carbides, Ampcoloy alloys, Cop-R-loy steel sheets.

-o Like the words in Italian Grand Opera, seems to be used more because it sounds well than on account of any particular meaning: Directo bat-

SYMBOL of electric service is what this jolly looking character has become.

tery chargers, Breezo fans, D-Tach-O lighting reflectors, Sealo liquid insulator.

-ohm Is a "natural" for resistance devices: Dividohm resistors, Ribohm resistors, Thermohm electric thermometers.

-oid Is a suffix indicating resemblance, inherited from the Greek through geometry, zoology, and other ologies: Flexoid flexible shaft couplings, Ohmoid insulation, Fyberoid insulating paper, Mercoid switches.

-ol Is another suffix taken over from chemistry: Protectol waterproofing liquid, Chlorextol insulating liquid, Pyranol transformers.

-tor Has approximately the same meaning as "eer": Circoolator fans, Terminator potheads, Ruptor circuit breaker, Climator air conditioners, Coffeelator you-guess-what.

-tron Comes from the Greek and is handy to convey the idea of a device: Fusetron cutouts, Actron rectifiers, Selectron controls, Lumotron photo-electric cells.

Numerous other current prefixes and suffixes lend themselves to the coining of trade names, and others still more numerous can be made up from syllables extracted from words suggestive of the goods under consideration. Before a particular trade name is adopted, however, a thorough investigation should be made. Among other things, it is important to make sure that it is not too close to names already in use on similar goods, that it is not objectionable to foreign speaking customers, and also, preferably, that it is registerable.*

* See "Concerning Trade Marks" by Leo Teplow, Electrical Review, December 1937, pages 17-21.

ON FOLLOWING PAGES: Driven by two 1,000 horsepower and one 600 horsepower motor, three centrifugal refrigeration machines chill the water circulated through the air supply unit in the air conditioning system of one of the new windowless war plants.


CHALMERS

ELECTRONICS—FROM CURIOSITY TO WORLD POWER

Although the facts can't be told now, electronics has revolutionized war production and materiel. Here is a cross-sectional view of commonly-known applications of electronics.

William Guyton

ELECTRONIC DEVICES SECTION • ALLIS-CHALMERS MANUFACTURING COMPANY

● Many engineers are familiar with some of the uses of vacuum tubes and associated circuits, but have little idea as to the vastness of the subject and the many applications made in the past years. Without some knowledge of the great strides that have been made in the field of electronics and its diversity of uses, it is difficult to consider intelligently the many possibilities and advantages to be gained. Wartime achievements, of course, have been tremendous, and while this chapter in the story of electronics largely remains untold for now, its import for the post-war years is great. Successful electronics applications have been made in so many directions, however, that a cross-section of those which can be described offers a good idea of what is to come.

To begin with, the industrial and home products to which electronics has already been applied would now provide quite an imposing list; after the war, with the facilities and knowledge of war plants turned to peace-time production, this list will increase many fold.

Most familiar of all, the communication field has done by far the largest dollar-and-cents business in the application of electronic principles. And the number one item is, of course, the radio, long a common object in millions of homes.

For industry, the photo-electric tube or electric eye was the first electronic device to be widely applied, doing a job better, generally with greater speed and dependability, than was possible by other means. From the novelty of a drinking fountain control, this little photocell and its electronic circuits has expanded its usefulness to hundreds of successful applications having far greater effect on the progress of industry.

Industrial uses of photocell

The photocell has found industrial use as a loop regulator, for example, easily doing a job that was difficult to do by other means. It is often important in the paper, textile and steel industries to control the loop of material hanging between two sets of rolls, generally to assure the correct tension on the material and to eliminate a taut condition which might result in a costly breakdown. In the processing of sheet steel strips, the photocell controls the length of strips hanging in loops between the mill coil winder and the last processing roll. One design of this control equipment makes use of two photocells—one to limit the maximum loop, the other to limit the minimum loop. As either extreme is reached, a light beam is interrupted and the control circuit acts to remedy the condition by changing the roller speed.

Industrial illumination has found a further use for the photocell. Lights in an office building or factory are automatically turned on and off to maintain proper intensity of light. Although this kind of control saves power in many cases, it is really important for improving the quality and quantity of production. The lights are off unless actually required by the principles of correct illumination. A noticeable increase in efficiency of personnel is found when the light is correctly regulated in this manner. Maintenance costs are found to decrease when random manual switching on and off of the lights is replaced by a control governed by a photocell receiving an input dependent on the intensity of illumination in the area.

The printing industry has been one of the many to apply electronic principles to controls of all types. Automatic machine setting of type from reporter's typewritten copy, automatic control of accurate trimming of paper, and automatic stops for presses (preventing expensive paper breaks) are examples of the variety of the automatic control circuits possible in this industry. Electronic equipment has also provided the means for matching colors of inks and papers, permitting permanent color records reproducible at any time with proof against fading or change. In an allied use, the photocell is often called into service to perform the job of controlling the register of the printing, as well as the precise cutting of wrapping paper, maintaining high speed with a reduction in the chance of error.

The silk manufacturers have long been interested in the problem of securing uniformity of size or diameter of thread. A device was developed a number of

AT RIGHT: This 25 kilowatt electronic generator for induction heating will convert 60 cycle power to 400,000 cycle high frequency power. The high frequency will be used in a work coil for annealing, soldering, brazing, or melting metals or metal parts.

Fig. 1 — Three-tube cathode ray oscillograph (above) is used in Allis-Chalmers electronics research in developing a new electronic control circuit which may be applied to industrial products.

years ago to enable the manufacturer to determine the quality of the stock. Samples of the purchased silk are wound by this device on a block board with about 100 threads to the inch. If the thread is not uniform in size, the coarse and fine parts show up as light and dark bands. Formerly such bands were visually noted and hence graded by inspection. The photocell control now replaces the human eye in this process, the amount of light impinging on the photocell varying with the diameter of the silk thread.

Variable a-c electronic control

For a number of years, plants equipped only with a-c power supply have been bothered with a particularly important question—how is it possible to secure a variable speed a-c motor that is dependable? Manufacturers and operators of printing presses, textile mill machinery and steel mill rollers looked for years for some possible means of getting a good variable speed motor that could be inexpensively attached to the a-c power lines. The Schrage motor, a variable speed a-c motor, provided part of the answer to their problem, and the printing industry found these acceptable for a long period of time. Then, as was natural, something just a little bit better was demanded—a machine with closer speed regulation, smoother accleration, better mechanical characteristics. The solution came, not in the form of large conversion units, but in the use of thyratron tubes and accompanying circuits. The advantages that have been achieved with this equipment are nearly as numerous as the wide line of applications in which this control unit can be placed.

Problems of vibration are relatively unimportant in small generators, but they are a great factor for consideration when conducting tests on larger generators. It is advantageous to have an alarm system to give warning when the generator reaches the safe limits of vibration and to trip out the line when passing these limits. Such an alarm system is made practical by the application of electronic principles. A vibration pickup, with output proportional to the amount of vibration, can be mounted on the outboard generator bearing to feed an amplifier and relay. The entire system is simple, yet accurate enough to do the job satisfactorily.

In the piping of gases and liquids over long distances usually no adequate method for ascertaining remote pressure and rate of flow was utilized. As a result, consumers were frequently inconvenienced by low pressure, or excessive losses due to needlessly high pressure. To furnish information regarding conditions at remote points, a telephone report was usually made by an attendant reading a meter at the desired spot. Now, an electronic system provides for accurate, instant information on the conditions at remote points in the mains. The ability of the system to transmit information over the simplest type of lines, over any type of superposed circuit (such as power lines) and over long distances is an important advantage.

In this application, the conditions of pressure or rate of flow at the remote point automatically adjust

Fig. 2 — This d-c electronic type welder (at left) is particularly adapted to the welding of thin metals. The 75 ampere, 220 volt, single phase unit is known as the Weld-O-Tron.

a variable condenser in an oscillator or electronic generator. This varies the output frequency of the unit, so that at the receiving end definite pressure and flow conditions are received as certain assigned frequencies. By calibration of a frequency meter to correspond to what is being measured, it is possible to read pressure or flow directly. Voltage variations along the line do not affect the readings, since the entire system is dependent on frequency variations alone. It is possible to connect several receivers to one transmitter so that indications are recorded simultaneously at different points.

Aid to oil prospecting

In seismic prospecting for oil products, a charge of dynamite is detonated in a hole in the ground. The reflected sound waves return from underground strata to the surface to actuate pickups, called geophones, placed at predetermined positions in relation to the shot point. The output voltages of the geophones are suitably amplified and fed to recording oscillographs enabling accurate mapping, in three dimensions, of the local sub-surface structure of the earth's crust. Such an electronic aid to oil prospecting is invaluable.

American oil companies make an annual expenditure of about twenty millions of dollars in seismic prospecting equipment of the electronic type and skilled personnel to operate it. This represents the interest taken in such equipment by the oil industry. For now it is providing the means to locate valuable and much needed oil reserves, and such equipment will become more and more in demand as the oil supply dwindles.

Similar to industrial applications is the Novachord, an electronic musical instrument from start to finish. Although not intended to duplicate any existing musical instrument, the Novachord duplicates partially the tonal qualities of the organ, piano, woodwinds and harp. Considering the complexity of the instrument and the fact that it has 163 vacuum tubes, it is extremely compact, the entire unit occupying as little space as a square about four feet on a side.

Uses in medicine, aviation

Electronics has also found its place in the field of medical science. The Oximeter is a typical development in this field. Its function is to record automatically and instantaneously the oxygen content of a person's blood. The application of this instrument has been for the greater part devoted to studying reaction of the human body under conditions of varying atmospheric pressure. And in research devoted to the problems of high altitude flying, the Oximeter has proven an invaluable aid.

Small units are made for the use of the crew members in a plane flying at high altitudes. The individual then knows his condition at all times and has accurate information as to how to regulate the oxygen flow to his mask worn during flight. Many times when an individual is subjected to the rigors of high altitude flight it is impossible for him to judge from his own feelings just how well he is. The Oximeter indicator is foolproof and eliminates a great deal of the risk of high altitude flying.

The Oximeter is based on the principle of change in color of blood with oxygen-content change. A small photocell attached to the subject's ear will receive a light beam through the ear tissues, the amount of light received depending on the thickness of the subject's ear and the oxygen content of the blood. Adjustment is possible for the initial condition of ear thickness, so the variable oxygen content of the blood can be readily measured.

The foregoing applications of electronics represent but a very few uses for these principles. Industry has called upon electronics for more accurate controls, for rectifying alternating-current to direct-current, for countless ways to speed production, increase efficiency and improve quality of production. Beyond any question the superior dependability of electronic controls has already been proved, and from an economic standpoint their record is highly satisfactory.

Fig. 3 — On the above equipment, new electronic control circuits are being developed in one of the electrical laboratories.

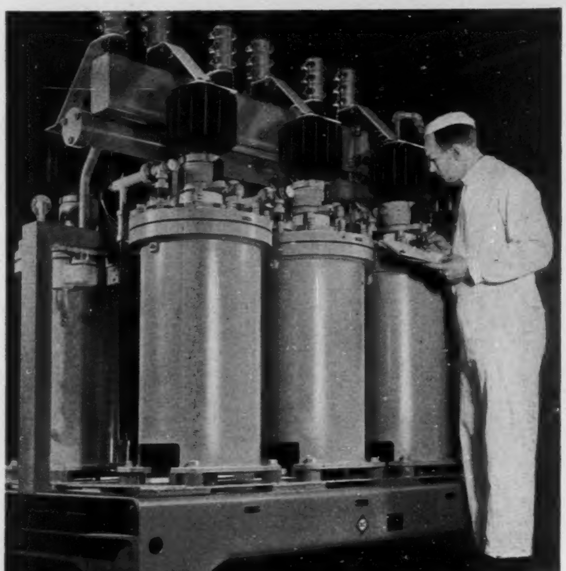


Fig. 4 — This Excitron mercury arc rectifier, for electrical conversion of 250 volts and up, is representative of what has proved to be a highly successful power application of electronic principles.

Fig. 1 — Cores for bushing current transformers are produced by wrapping alloy steel strip. Completed cores are in foreground.

Fig. 2 — Secondary winding is applied to insulated alloy steel core for large bushing current transformers like this.

Fig. 3 — Complete bushing current transformers are ready for installation in a 115,000 volt outdoor oil circuit breaker.

Fig. 4 — Into the 115,000 volt outdoor oil circuit breaker goes one of the bushing current transformers manufactured in these operations.

"WHEN" AND "WHY" TIPS ON BUSHING CURRENT TRANSFORMERS

Bushing type current transformers are just what the engineer ordered for some applications. Here's what they are and how their performance can be checked.

H. B. Ashenden

SWITCHGEAR DIVISION • ALLIS-CHALMERS MANUFACTURING COMPANY

● Bushing type current transformers are standard accessories for outdoor type oil circuit breakers and are invariably used wherever their characteristics permit. They have considerable advantages over separately mounted, outdoor, wound primary type current transformers except at relatively low ratios. The cost is lower, no space is required in the switchyard for mounting, they are integral with the breaker, multiple ratios can easily be provided so that purchase of new transformers is not necessary when circuit conditions change, and insulation as well as mechanical and thermal limits are those of the breaker itself.

Of these advantages, the matter of cost is perhaps the most important. For example, at 46 kv the installed cost of a bushing current transformer is about one-fifth the uninstalled price of an outdoor wound primary type current transformer. At 161 kv this cost ratio is nearer 10 to 1 in favor of the bushing current transformer.

While cost is important, there are some applications for which the bushing type transformer is not satisfactory because its characteristics at relatively low ratios are poor compared to the wound primary type. The ratio error tends to increase as the ratio decreases. Hence, bushing current transformer applications often require careful checking to insure satisfactory performance. Heretofore, the user has had some difficulty in doing this with reasonable accuracy, but the recently revised ASA and NEMA Standards have improved the situation by establishing more readily usable standard application or performance data.

Description and limitations

For the benefit of those who only occasionally deal with this kind of transformer application, it would be well to start with a description of a bushing type current transformer. According to ASA Standards (4.011d), "this type has a secondary winding completely insulated and permanently assembled on the core, but has no primary winding nor insulation for primary winding. The bushing type transformer is intended for use with a primary winding consisting of a completely insulated conductor. This conductor is usually a component part of other apparatus with which the design of the bushing type current transformer must be coordinated."

On a circuit breaker, the bushing, which consists of a straight copper conductor surrounded by insulation (usually porcelain), acts as the single conductor primary. The transformer is usually mounted just below the mounting flange of the bushing and its inside diameter must be larger than the bushing diameter at that point. The maximum outside diameter and the height of the transformer are limited by the space available around the bushing. In turn, the space for bushing current transformers in outdoor oil circuit breakers is limited by other design factors. These limits sometimes tend to affect adversely the current transformer design and its characteristics.

The transformer core usually takes the form of a complete ring, or hollow cylinder of laminated alloy steel with no air gap. Many of these cores are made by wrapping or coiling alloy steel strip around a mandrel, as shown in Fig. 1. The completed core is annealed and then insulated and the secondary wound on by hand. (See Fig. 2.) The completed transformer is tested to insure that the insulation and winding are correct, and that the transformer characteristics conform to established standards. Fig. 3 shows two large bushing current transformers ready for installation in a 115 kv oil circuit breaker. Fig. 4 illustrates the method of installation. After the transformer is in place the leads are connected to terminals in an adjacent terminal housing and the entire installation is given a hi-pot test to ground and is ratio checked.

Ratio errors

All current transformers have some ratio error, although it may be extremely small over a limited current range for high grade, wound type and high ratio, bushing type current transformers. If these errors were constant or even varied uniformly with the current, they could easily be compensated for, but like all ferrous materials the alloy steel cores do

not have linear magnetic characteristics, and consequently the transformer characteristics cannot be linear except over a small range. The error is due to the exciting ampere turns required to magnetize the core and supply the losses. If the total ampere turns is large compared to the exciting ampere turns, the error is small. On a wound primary type transformer this can be achieved by using a number of primary turns. On a bushing type transformer there is only one primary turn, and, consequently, the total ampere turns equal the primary current.

Assuming that the 100/5 and 1000/5 ampere taps of a multi-ratio bushing current transformer are connected alternately to the same burden, at rated current the secondary will be 5 amperes in both cases and, since burden and core are the same for both ratios, the exciting ampere turns will be the same in each case. Supposing five ampere turns are required to provide excitation, then with 100 primary amperes on the 100/5 ampere ratio there will be only 95 ampere turns available to induce current in the secondary, and the error will be 5 percent; or alternatively, 105 amperes primary will be required to produce a 5 ampere secondary current. With 1,000 amperes on the 1000/5 ampere tap there will be 995 ampere turns available to induce current in the secondary, causing an error of only 0.5 percent. Thus the error decreases as the ratio increases.

At any particular frequency and ratio the error depends chiefly on the proportions of the core, the magnetic characteristics of the steel used, and the connected burden. For best results, the connected burden should be as small as possible, permeability of the steel should be high over the useful current range, the mean diameter of the transformer should be small, and the cross-sectional area large. The core diameter is determined by the size of the bushing and the other dimensions depend on the available space.

Choice as to core material is restricted, the most useful core material for the average application being a grade of high silicon steel selected for high permeability. It is commercially available in quantity, not too expensive, retains its magnetic characteristics indefinitely, and is relatively easy to handle and anneal properly. Nickel steel alloys are occasionally used because they have higher permeability than silicon steel at low induction, but the permeability is lower at high induction. Their application is limited, therefore, principally to metering transformers which have to provide exceptionally good performance at low currents and burdens. Nickel steel is difficult to anneal and is high in cost. Transformers made with this material are necessarily expensive.

New standards approved

Until recently the only bushing current transformer standard was NEMA SG6-50 which dealt with standard ratios, polarity, method of marking, etc., but did not include accuracy classifications. Consequently, the user had little assurance that different manufacturers' transformers would have similar characteristics unless his requirements were written into his specifications.

In this manner, performance characteristics which were difficult and expensive to meet were often specified. Competition between manufacturers created a progressive improvement in bushing current transformers, and the performance characteristics of competitive transformers did not vary greatly. Nevertheless, the user could only be sure by comparing ratio curves. Since this situation needed correction, a current transformer standardization committee included bushing current transformers in its work.

Late in 1942 ASA Standard C-57.1 for transformers, regulators, and reactors was approved. Section 4 covers instrument transformers and applies to all types including bushing transformers. This Standard establishes standard burdens and accuracy classes and provides for standard application data. In 1943 NEMA Standard SG6-50 for outdoor oil circuit breaker bushing current transformers was revised to conform to the new ASA Standard, and a new Standard SG6-51 was added to cover accuracy classifications and performance data. This included a table which lists the accuracy required of the standard bushing current transformer for each standard rating of outdoor oil circuit breaker. Performance data in considerable detail is also included.

While the new standards include separate accuracy classifications for metering and for relaying, there is not necessarily any sharp dividing line between transformers intended for different services. For example, a high ratio bushing current transformer primarily intended for relaying may well meet one of the metering accuracy classes. However, for metering service, only the narrow range from 5 to 150 percent of rated current need be considered. Over this range the ratio errors must be relatively small, and consideration must be given to the phase angle. Accordingly, bushing transformers for metering are usually made single ratio and are compensated for one of the standard meter burdens to give the best possible accuracy over the metering range. For relaying, the characteristics of the transformer throughout the overcurrent range from 1 to about 20 times rated current are of interest. A considerably larger error can be tolerated, and the phase angle can be neglected for most applications. Such transformers are not usually compensated and are generally made multi-ratio.

Performance data

The article "Now Instrument Transformer Standards Make Sense" by Mr. F. E. Davis, which appeared in *Electrical Review* June, 1944, discussed the new standards for metering transformers in considerable detail. Typical performance data for bushing current transformers consists of ratio and phase angle curves as shown in Fig. 5.

As application data established by the Standards is not covered in this article and it is particularly useful for bushing transformers for relaying service (probably their most frequent application), it seems desirable to discuss the form and method of use here. But first, why is a form of performance data other than the accuracy classification necessary?

The characteristics of a metering transformer are well described by its standard accuracy classification, which sets definite limits of error at both 10 and 100 percent rated current, and no further information is usually necessary to determine the correct application. The standard accuracy classification for a relaying transformer, on the other hand, is made at only one point of its characteristic and does not give much information as to the performance at a particular burden and current. For example, an accuracy class of 10L200 means a low internal impedance transformer

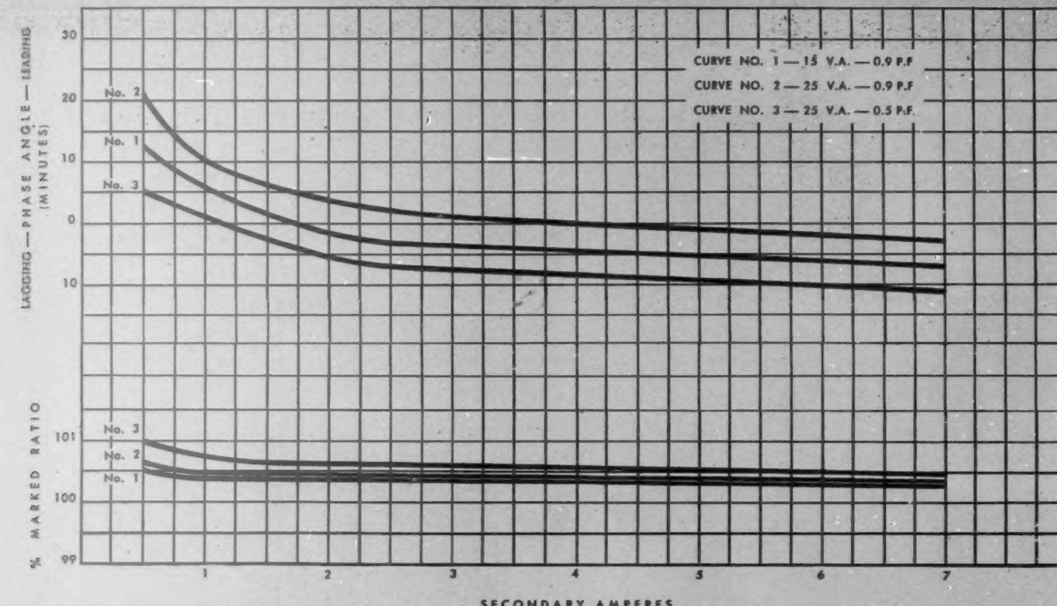
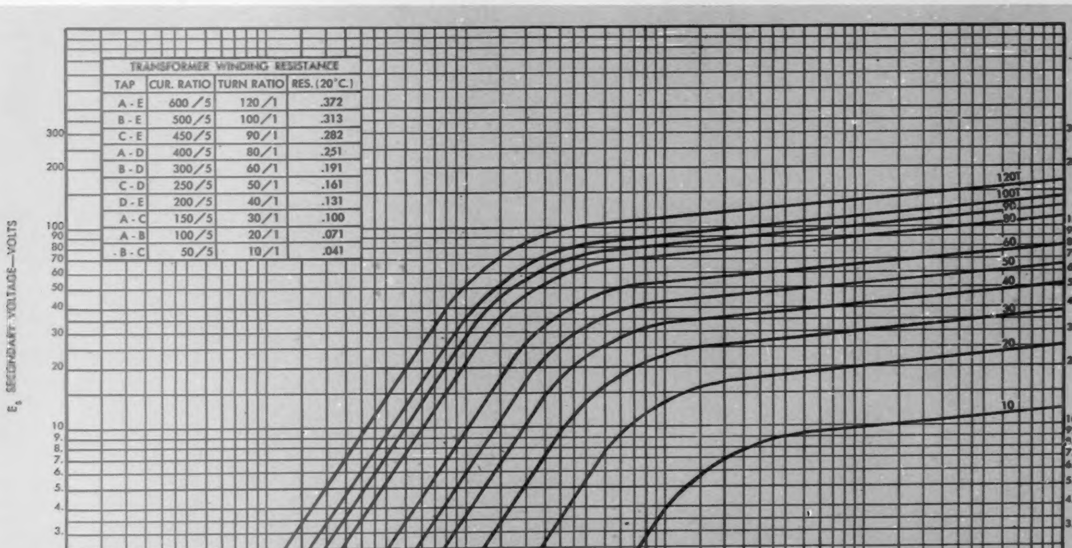


Fig. 5 — Typical ratio and phase angle curves for a bushing current transformer for metering service, operating at 60 cycles, current ratio 100/1, 500/5 amperes, and 34.5 kv. (The phase angle is the angle between the primary current vector and the secondary current vector reversed . . . conveniently positive when the reversed secondary current vector leads the primary current vector.)

which has a ratio error not greater than 10 percent at 20 times rated current with a burden which does not require more than 200 secondary volts; i.e., a B2 or 2 ohm burden for a standard transformer with a 5 ampere secondary. In other words, a 10 ampere exciting current will produce an open circuit voltage of 200 on the secondary.

Now, bushing current transformer characteristics generally are such that the ratio error of this transformer will be less than 10 percent between 1 and 20 times rated current with a 2 ohm burden, but just what the error is or what the performance will be at some other burden is not readily apparent. It is often necessary to check bushing current transformer applications, particularly for relaying, and to do so it is necessary to find the ratio error at the actual current and burden of the application. This can be done with sufficient accuracy for practical purposes by referring to standard performance data and by making simple calculations. The method is by no means precise, but the order of accuracy is probably as high as that of the data available in most cases. Relays, for example, usually include iron cores which produce variations from average impedance values upon which the burden data is based.

Excitation curves were chosen as the best available



TRANSFORMER WINDING RESISTANCE			
TAP	CUR. RATIO	TURN RATIO	RES. (20°C.)
A - E	600/5	120/1	.372
B - E	500/5	100/1	.313
C - E	450/5	90/1	.282
A - D	400/5	80/1	.251
B - D	300/5	60/1	.191
C - D	250/5	50/1	.161
D - E	200/5	40/1	.131
A - C	150/5	30/1	.100
A - B	100/5	20/1	.071
B - C	50/5	10/1	.041

Fig. 6 — Typical excitation current-voltage curves for 600 ampere multiple (10) ratio bushing current transformers. They are used in 46 kv outdoor oil circuit breakers for relaying service.

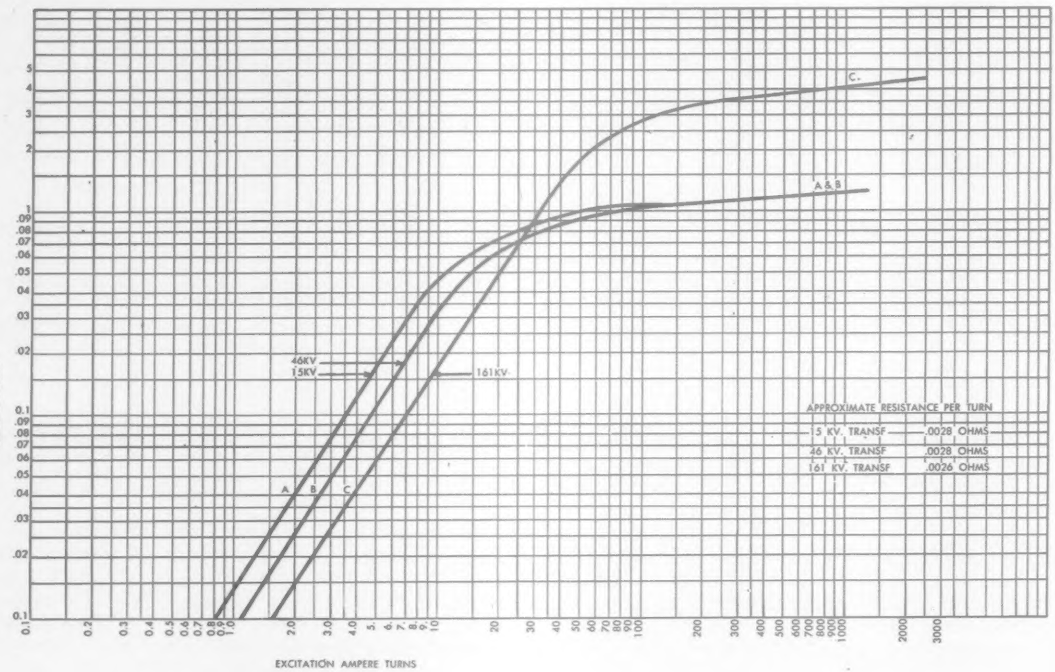


Fig. 7 — Typical excitation ampere turn — volts per turn curves for bushing current transformers, also for use with outdoor oil circuit breakers in relaying service.

method for presenting current transformer application data. A typical set of excitation curves for a 600/5 ratio relaying transformer installed on a 46 kv breaker is shown in Fig. 6. On the full 120 turn winding, the secondary voltage for a 10 ampere exciting current is about 138 volts, which is higher than 100 but less than 200. The transformer, therefore, has an accuracy classification of 10L100.

These curves are plotted from averaged data of tests on several typical transformers and are reasonably accurate. Individual transformers will have characteristics which do not follow these curves exactly because of unavoidable manufacturing variations.

Another form of application data, which is sometimes published as catalog information, consists of typical excitation curves plotted in volts per turn versus exciting ampere turns. Fig. 7 shows the excitation characteristics of standard transformers for breakers of three widely different ratings plotted together for comparison. Curve A applies to any transformer for a 15 kv, 100,000 kva oil circuit breaker using a given core, Curve B to a 46 kv, 500,000 kva, and Curve C to a 161 kv, 2,500,000 kva oil circuit breaker. A and B are both class 10L100 accuracy while Curve C is class 10L400 on 120 turn tap.

Performance checking

A description of the method of using the standard performance data or excitation curves will probably be of interest to those who have not previously used them. To begin with, it is necessary to know the total burden on the transformer and the current at which it is expected to function. The burden consists of the sum of impedance of all connected relays, instruments and meters in ohms, plus the resistance of the leads between the transformers and the load and the resistance of the transformer winding itself. Theoretically, the vector sum should be used but the arithmetical sum greatly simplifies the calculation, and the error introduced by this approximation is negligible for most applications. The product of the burden and the secondary current at which operation is desired gives the secondary volts. From this voltage, the exciting current can be found directly from the curve (see Fig. 6), and the total primary current required is then the sum of the theoretical primary current required for a transformer without losses plus the exciting current.

As an example, assume it has been decided that relaying for a 46 kv breaker requires a 4-15 ampere induction type overcurrent relay with 10-40 ampere instantaneous trip attachment with direct current tripping from a battery; the relay to be connected to the 200/5 ampere (40 turn) transformer tap; time overcurrent setting 5 amperes; instantaneous setting 20 amperes. If the transformer had no ratio error, the breaker would trip with time delay at 200 (5 x 40) amperes and without time delay at 800 (20 x 40)

amperes primary. At what primary current will the breaker actually trip if the standard 46 kv bushing type current transformer is used?

Assume the following values are found —

Relay impedance	0.6 ohms
Lead resistance	0.5 ohms
Winding resistance	0.13 ohms (Fig. 6)
Total burden	1.23 ohms

For time delay trip —

Secondary volts = 5 x 1.23 = 6.15 volts

Secondary exciting current = 0.14 amps. (from 40 turn Curve, Fig. 6)

Primary exciting current = 40 x .14 = 5.6 amps.

Primary current required to trip breaker = 205.6 amps.

$$\text{Ratio correction factor (RCF)} = \frac{205.6}{200} = 1.028$$

For instantaneous trip —

Secondary volts = 20 x 1.23 = 24.6 volts

Secondary exciting current = 0.46 amps. (Fig 6, 40 turn Curve)

Primary exciting current = 40 x .46 = 18.4 amps.

Primary current required to trip breaker = 818.4 amps.

$$\text{Ratio correction factor (RCF)} = \frac{818.4}{800} = 1.023$$

Isolated breaker analyzed

Now consider the rather common case of a small 15 kv breaker in an isolated location with no tripping battery available. Assume accurate current and time settings not essential, trip coils with dashpot timing connected directly to current transformers as satisfactory and tripping required at about 60 amperes primary. If a wound primary transformer were to be used, it would probably be safe to assume that a 50/5 transformer connected to a 5 ampere trip coil set to trip at 6 amperes would provide tripping close enough to 60 amperes for practical purposes. Such an assumption is not safe when using bushing transformers as will be apparent from the following calculation:

Total burden: trip coil, leads and winding 1.6 ohms

Secondary volts = 6 x 1.6 = 9.6 volts

$$\text{Volts per turn} = \frac{9.6}{10} = 0.96 \text{ (10 turn secondary)}$$

Exciting ampere-turns (from Curve A, Fig. 7) = 45

Primary current required to trip breaker = 60 + 45 = 105 amperes

Then will a 3 ampere trip coil connected to the 100/5 ampere (20/1) tap produce the desired operation?

Total burden: trip coil, leads and winding = 4 ohms

Secondary volts = 3 x 4 = 12 volts

$$\text{Volts per turn} = \frac{12}{20} = 0.6$$

Exciting ampere turns (from Curve A of Fig. 7) = 14

Primary current required to trip breaker = 60 + 14 = 74 amps.

Obviously some alternative method of tripping must be found and probably the most practical solution would be to use a 5 ampere trip coil set to pick up at 5 amperes, connected to the 50/5 ampere taps of two current transformers in series. Since all three pole, outdoor oil circuit breakers have provision for at least one (two as a special application on large breakers) bushing current transformer per bushing, or a total of six transformers per breaker, the two transformers per phase could probably be accommodated. Then assuming each transformer carries half the 1.6 ohms burden —

Total burden: trip coil, leads, and winding = 0.8 ohms

Secondary volts = 5 x 0.8 = 4 volts

$$\text{Volts per turn} = \frac{4}{10} = 0.4 \text{ (10 turn secondary)}$$

Exciting ampere turns = 8.8 (from Curve A of Fig. 7)

Primary current required to trip breaker = 50 + 8.8 = 58.8 amperes

Obviously this is the correct solution of the problem.

Safety factor advisable

In general, when the above method is used to check bushing current transformer applications with the approximate burden information usually available, it is advisable to allow a small safety factor. If the calculation shows that a particular combination produces errors which are only barely within permissible limits, it is well to assume that the error may be beyond the limits when actually installed. If it is decided that a standard transformer will not be satisfactory, three main alternative courses of action are usually available.

The first, and usually the least expensive, is to adopt every expedient to reduce the connected burden, such as larger cross-section leads, a different type of relay, connection of some equipment to other current transformers and location of the relays nearer to the bushing current transformer.

Secondly, it may be possible to furnish a somewhat special bushing transformer with better characteristics. Often, the standard transformer is the best that can be furnished in the space available, but it is possible in a few cases to provide transformers which will be more suitable for a definite application. In such cases the additional expense may be considerable.

The third alternative is to purchase wound primary type current transformers. This is usually more expensive than the other two alternatives, but is sometimes the only satisfactory solution, particularly for accurate operation at very low primary currents.

Conclusion

Bushing type current transformers, as installed in outdoor oil circuit breakers, are a convenient and economical alternative to other types of current transformers for both relaying and metering applications, particularly at the higher voltages and currents. However, checks should be made to insure that errors will be within permissible limits over the range of operation of a particular application and the new standardized performance data facilitates such checking.

"TAKE 'ER DOWN!" IS THE BIG TEST FOR A SUB'S MACHINERY

When a submarine suddenly converts to underwater operation, a complex changeover must take place—infallibly! Modern equipment sacrifices little flexibility of control, even underseas.

Ensign John A. Logan

FORMER FIELD ENGINEER • ALLIS-CHALMERS MANUFACTURING COMPANY

● When there's work to be done down under and the skipper passes that curt "take 'er down!" order, a sub invades another element . . . with seconds—*only seconds*—to prepare. In these vital, nerve-tingling seconds tremendous changes must take place. Men and machinery are seldom more dependent on each other . . . on faultless human control of machinery that *must not* fail.

In the tense moments that follow, lights on the control board flash the signal that all hatches are closed. The hull is quickly charged with air. Pressure readings reassure the crew every few seconds that there are no hatches open, no leaks in the hull. Diesel engines are stopped instantly, for in a few minutes they would draw all of the precious air out of the hull. Valves in the exhaust manifold close to prevent water from backing up into the engine . . . but not until the instant the engines stop. Otherwise exhaust gases prevented from discharging by the closed valves would build up high pressures in the manifold. Stopped immediately, too, are the compressors, which, while the vessel was on the surface, probably were busy storing air under pressure for blowing water out of the ballast tanks.

These changes directly or indirectly affect the control of air within the vessel. There are, in addition, a number of other mechanical changes which must be made as the ship submerges. Diving planes or "ears," normally folded into the side of the hull, must be lowered into position and ballast adjusted before complete control of the vessel is in the operator's hands. The diving planes control the angle of dive of the vessel. Direct-current transmitters and receivers indicate the angle of the planes. These planes operate comparably to the rudder, but are in a horizontal rather than a vertical plane.

The electrical propulsion equipment which has been operating on power supplied by the generators must be changed over to battery power supply. This, of course, is accomplished by cutting all of the generators from the line and connecting the battery bus to the motor bus. A relatively simple change, it takes only a few seconds. Since there are no generators in operation, speed control is now accomplished by a combination of motor field control and connecting the motors in parallel or series as required.

The resistance to forward travel is much greater under water than on the surface. Furthermore, the battery power output is limited. As a result, submerged speed is limited to a value considerably below that of surface speed. Since the submarine cannot remain still at any predetermined submersion, it must be kept moving at all times, unless it is resting on the bottom. This is where the so-called "creeping speed" comes into play.

Distinctive submarine design

Obviously there are certain features which make the propulsion and auxiliary electrical equipment of a submarine distinct and the design of its components somewhat complex, although such equipment is in many ways comparable to that of a surface vessel. Specifically, a submarine, while on the surface, must store up sufficient energy in its batteries to provide power for many hours of underwater operation. This means that electrical energy must not only be supplied for the propulsion motors, but for battery charging. Further, while most surface vessels have a fairly constant or a controlled variable voltage to supply main propulsion motors and auxiliary allied equipment, submarines during submerged operation must rely on the voltage of the battery terminals which will vary with the charge in the batteries. This means that motors must be designed to operate over a wide range of voltage and contactor holding coils and electrical interlocks must have their magnetic circuit designed to pick up at low voltage and yet not overheat at the maximum battery voltage at full charge.

Propulsion motors

The main propulsion motors often consist of four high speed, single armature, cumulative compound wound direct current motors, two for port and two for starboard, each pair connected through its own reduction gear to the port or starboard propeller shaft. Series

Fig. 1 — An odd, triangular wake follows this deadly underwater torpedo boat as it dives swiftly to ocean depths. Its rapid progress from element to element is made possible by control mechanisms which guide submerging and surfacing.—*U. S. Navy Photo.*

fields are to ensure equal division of load between motors geared to the same propeller.

Under operating conditions there are actually three major speed steps which may be obtained. These are, all armatures in series, all armatures in parallel, and series parallel connection. In starting the series parallel connection is normally used; that is, the two port motors and the two starboard motors are connected in series across the motor bus. As the motors accelerate, all four armatures are connected in parallel. Smooth acceleration between these two points is accomplished by means of either generator or motor field control. The third speed position, commonly referred to as the "creeping speed," consists of connecting all four armatures in series across the motor bus.

Submerged operation of propulsion motors is quite similar to that of surface operation except that power here must be supplied by batteries alone. Armatures may be connected in series or parallel, depending upon the speed desired. The third position of all armatures in series is quite often used when the submarine is under water. Since generators are not operating when the vessel is submerged, and further, since there is no control of the battery voltage, starting is by means of starting resistances in each motor armature circuit and intermediate speed points obtained by motor field control.

Generators

The total generating capacity is produced by four main generators and one auxiliary unit. All units are Diesel engine driven. The generators must not only be designed to supply power to the main propulsion motors, but they must also recharge the batteries during surface operation after prolonged submerged operation. During normal surface operation, one, two, three or four generators may be used to supply main propulsion power.

Due to the desirability of having isolated electrical systems for the port and starboard propellers during maneuvering, the generator bus may be sectionalized and power supplied and independently controlled for the port and starboard motors.

The auxiliary generator is floated across the battery to supply auxiliary power while the craft is on the surface, and also to keep the batteries at full charge. When a vessel has been submerged for long periods of time, it is sometimes necessary to employ more than one of the main generators in supplying charging power after the submarine has surfaced. It would not, however, be practical to use a main generator in topping off the battery charge, since the power requirement is small and the efficiency of the main generator when delivering this small amount of power is very low. Consequently, the auxiliary generator is used.

Control

A typical control arrangement for the main propulsion motors and generators is shown in Figure 1. This diagram is in no way meant to be a duplicate of an actual submarine propulsion control, but it is typical,

CONTACTORS 1 THRU 16 — FORWARD & REVERSING MOTOR CONTACTORS
CONTACTORS 17 AND 18 — SERIES OPERATION CONTACTORS
CONTACTORS 19 THRU 22 — PARALLEL OPERATION CONTACTORS
CONTACTOR 23 — DEAD SLOW CONTACTOR
CONTACTORS 24 THRU 27 — MAIN LINE MOTOR CONTACTORS
CONTACTORS 28 AND 29 — BUS SECTIONALIZING CONTACTORS

CONTACTORS 30 THRU 33 — GEN. MOTOR BUS TIE
CONTACTORS 34 THRU 49 — GENERATOR
CONTACTORS 50 AND 51 — FORWARD BATTERY
CONTACTORS 52 AND 53 — AFT BATTERY
CONTACTORS 54 AND 55 — AUXILIARY GENERATOR
CONTACTORS 56 THRU 59 — MOTOR STARTING

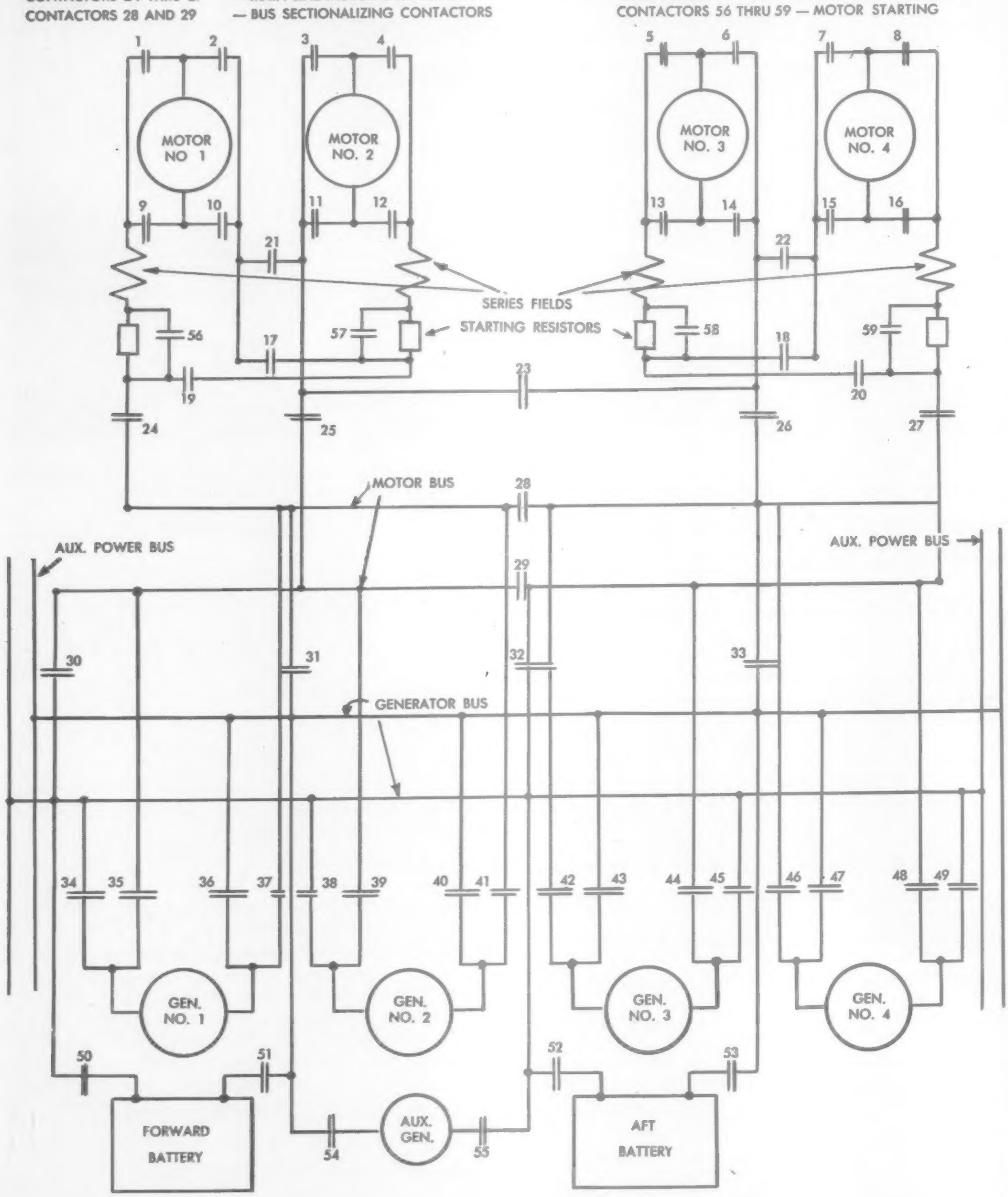


Fig. 2 — Power and control plan for a submarine. NOTE: Generator and motor shunt fields and generator series fields are not shown.

Fig. 3—"Up scope!" and the lethal eye of the submarine, commanding officer at the lens, scans the horizon for possible targets among enemy shipping or war craft. Other crew members watch the control panel instruments, check gauges and valves with confidence in their flawlessly coordinated equipment.—*U. S. Navy Photo.*

and indicates how various combinations of electrical circuits are attained.

While there are a number of contacts indicated in this diagram, many of them do not have to break load current, but do have to carry it. Although they are designed to carry the full load current, these manual contactors are not equipped with blowout coils. While this diagram does not show the excitation circuits for any of the machines being energized from the battery, this information is not required to understand the function of the propulsion equipment.

Assuming that the Diesel engines have been started and the generators are running at their rated speed, in order to start the propulsion motors it is necessary to close the series contactors (17 and 18), the forward contactors (1, 10, 12, 3 for port and 5, 14, 7, 16 for starboard), and the main line contactors (24, 25, 26 and 27). This connection will result in the two port and two starboard motors each being connected in series with the starting resistors across the motor bus with polarity correct for forward motion. The motors then accelerate to a low speed. When the starting current inrush has passed, contactors 56, 57, 58 and 59 are closed, short circuiting the starting resistors and causing full voltage to be applied to each pair of motors which then further accelerate.

The propeller speed may then be further increased by raising generator voltage and engine speed or decreasing motor field excitation up to about half speed. If higher speeds are desired, the series contactors (17 and 18) are opened and parallel contactors (19, 20, 21 and 22) are closed, connecting all four motors in parallel across the motor bus. When transfer is made, the starting resistors are again placed in the circuit and subsequently shorted out to minimize the current inrush occasioned by transfer from series to parallel.

It may be seen that when the two bus tie contactors (28 and 29) are open, the port and starboard electrical systems are completely isolated and the speed of each propeller can be controlled separately by using port and starboard motor and generator field controls separately. Should a boat be under way, the bus tie contactors (28 and 29) may be closed and three generators used to supply the full propulsion power. This is the normal operating position under standard speed ahead on the surface.

Astern operation can be had under any of the above conditions by merely opening the forward contactors and closing the reversing contactors (2, 4, 9, 11 for port, 6, 8, 13 and 15 for starboard). These contactors are connected between the armature and the series field, thus reversing only the potential across the armatures. This means that both leads on the series field must be brought out to the control board. Reversal of the series field would result in weakening the net field flux, giving the motor a differentially compounded effect under astern operation.

For extremely slow speed, either submerged or on the surface, a third combination is obtained by closing the dead slow (23) contactor and opening contactors 25 and 26. It is assumed the motors are connected for series parallel operation prior to this change. This results in all four armatures being connected in series and across the motor bus, and the position is referred to as the "dead slow" or "creeping" speed.

In the generator scheme indicated in Figure 2, all four generators are arranged so that they may be connected to the motor bus, or to the battery bus for charging purposes. Under maneuvering conditions, the starboard and port electrical systems may be isolated, using two generators to supply the starboard motors and two to supply the port motors. Under "full ahead" operation, it is usually only necessary to use three generators, and the bus sectionalizing contactors are closed, leaving one main generator free for battery charging. With the combination shown in Figure 1 any one or more of the four main generators may be used for battery charging along with the auxiliary generator.

All of the contactors shown in the control scheme are cam operated through a lever system. Power is supplied manually by the operator through levers with thumb operated push button release. All operations

are electrically and mechanically interlocked so as to prevent misfunctioning of the equipment should the operator make a mistake.

Auxiliary power

To supply the many auxiliary motors that are installed on a submarine a d-c ring bus is connected across the battery terminals. Just as in land loop systems, a break in the bus will still permit power flow to any of the auxiliary equipment, thus giving additional insurance against power failure at the load. Under finishing charge conditions, the batteries on a submarine have a terminal voltage of approximately 300 volts. Under low charge conditions this voltage can drop down as low as 150 volts. This means that contactors must be designed to pull in at 150 volts, and yet not overheat when operating on a 300 volt supply. Further, speed control devices must be supplied on certain motors to control the speed when the battery voltage drops off after long hours of submerged operation. This is particularly critical in the case of small inverters for supplying 400 cycle a-c power. Fortunately, one of the larger auxiliary loads — the high pressure sure air compressors — is turned off before the vessel submerges.

Mechanical considerations

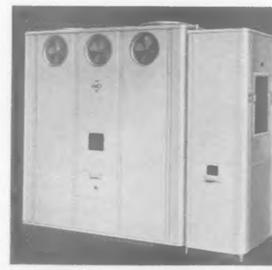
In addition to the above requirements for auxiliary power equipment, it is necessary that auxiliary motors and controllers be designed mechanically to fit the particular application. Although weight of these units is not a particular problem, it is extremely desirable that space be conserved. In many instances motors have to be built with long and small diameter armatures so that they will fit into the required space. Controllers also have to be designed with an eye to saving as much space as possible.

One of the common methods of detecting a submarine under water is with listening devices, so it is absolutely essential that motors be designed to operate very quietly. This means that air velocity through the motors must be kept to a minimum and siren effects eliminated. Further, bearings are very closely fitted to prevent bearing noise. Despite the fact that the auxiliary motors are small compared to the main motors, it is still necessary to consider noise elimination carefully in the proper design of the latter.

With the complexity of circuits, it is necessary that protection in addition to normal overload be supplied. Because of battery operation, reverse power relays are connected in all of the generator circuits. Protection is also provided to prevent the motor contactors from closing until the motor fields have built up to a predetermined value. Numerous electrical and mechanical interlocks are provided throughout the control panel, to make the control system as near fool-proof as possible.

Conclusion

From this brief review of a sub's machinery, it can be concluded that, when operating on the surface, submarine propulsion equipment has the same flexibility as that of any Diesel electric marine drive. In fact, even when operating submerged, very little flexibility of control is sacrificed, the main sacrifice being that of limited power and the effect of varying battery voltage.



New Dry-Type Transformer Has Induced Cooling For Overloading

A newly designed dry-type transformer has been introduced which embodies a unique cooling system as the most important development. This built-in system, called induced cooling, automatically provides extra cooling when the transformer is overloaded.

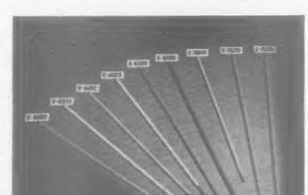
The new equipment includes a Z-section baffle which extends from one end of the transformer to the other, channelizing air flow. When temperatures reach the overload level, exhaust fans cut in, forcing cool air vertically through the core structure and horizontally between the coils.

Placed on the top and back of the transformer, the fans are protected by screening set flush with the metal casing which encloses all operating mechanisms.

Through streamlined design, the new transformer is attractive to the eye, provides protection to the workers and protection from dirt and water, and is easily adaptable with other elements of load center unit substations. Sectional panels provide easy access to the interior of the transformer, facilitating cleaning and maintenance.

The new unit is described in Bulletin B6344.

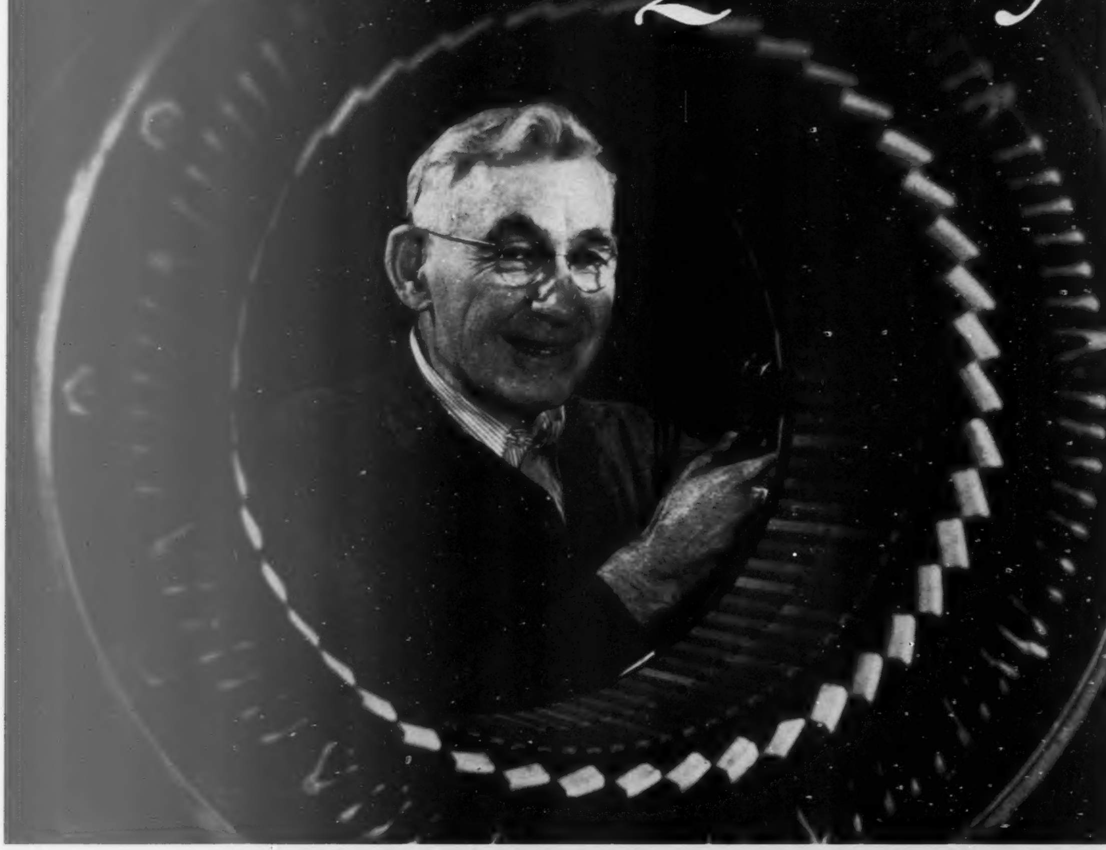
New Electrodes For A-c, D-c Use Have Quiet Arc



A new series of smooth - flowing arc welding electrodes with quiet arc characteristics is now available, supplementing a-c and d-c welders in the Allis-Chalmers line. The new electrodes use the standard American Welding Society number, simplifying selection and handling. A new bulletin, L6348, describes the electrodes. A price sheet, zone classifications, freight policy, quantity discounts, and term explanation are included.

For further, more detailed information regarding these new products, write the Editors of ELECTRICAL REVIEW.

Meet Mr. Quality



ONE LOOK AT Bill Seebode — 50 year man at Allis-Chalmers Norwood Works — tells you that he sleeps well nights.

One reason is that he and hundreds of his fellow craftsmen at Allis-Chalmers have won *and are keeping* the confidence of engineers and operating men throughout American Industry.

That means a lot to veterans like Bill who've made a career of building great motors.

Bill's a stator-winder, as you can see—a living example of the truism that *men* make motors.

No machine known can assemble the maze of wiring and insulation that goes into a stator with his skill and care. No machine can fully test how *well* he's done his job.

There's only one test . . . wait 5, 10, 15 years and *see.*

And that's the test that has proved Allis-Chalmers motors are *great* motors. That's why you hear it said so often: *"You can depend on Allis-Chalmers Motors!"*

Yes, hundreds of Allis-Chalmers men—*quality* men like Bill Seebode — know they have a big personal stake in every Allis-Chalmers motor. When they build a great motor for you, they're making a friend . . . and they know that's something no company and its workers can have too many of. ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN.

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A 1729

YOU CAN DEPEND ON ALLIS-CHALMERS MOTORS

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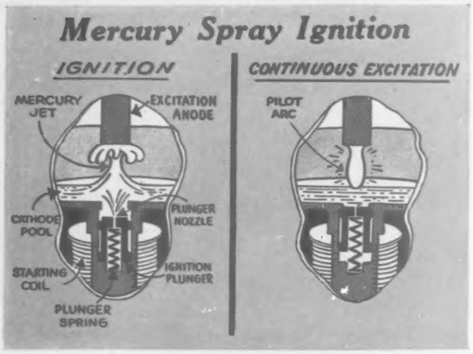
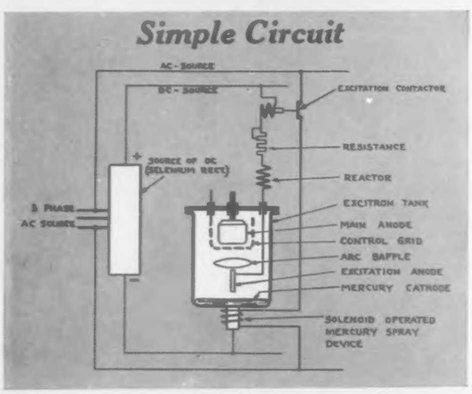


Allis-Chalmers' Excitron is the only mercury arc rectifier which gives you the advantages of "continuous excitation".

That means with Excitron there are no ignition impulses to be synchronized with main anode voltage. Tubes don't require re-ignition at start of each positive half-cycle.

Solenoid mercury-spray device creates small d-c pilot arc which keeps tube primed for firing while rectifier is in service.



Excitron is the only rectifier with a simple excitation circuit. Elements of circuit are familiar, commonly used. No "tuning" is necessary to maintain proper wave shape. Once adjusted and tested at factory, no further adjustment is required in the field.

Only Excitron takes direct current from a 3-phase source for excitation. Stability of excitation cannot be affected by average single phase dips in the a-c system voltage.

In Excitron, each anode has its own vacuum vessel and mercury cathode. That means compact construction, short arc, small arc-drop, high operating efficiency.

Allis-Chalmers engineers introduced mercury arc rectifiers to U. S. industry. Excitron is time-proven.

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